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Special Issue.
Nutritional Situation In Africa: An Update (UPNIA-2020)

Review Article

Zero hunger and malnutrition in the African continent is potentially feasible, if nutrition programs are prioritized politically and scientifically

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Abstract

African countries and in particular the Sub Sahara ones contribute to the largest proportion of the global burden of poverty and associated diet-related diseases in all its forms, including micronutrient malnutrition. Malnutrition rates remain alarming: and stunting an indicator of chronic malnutrition is declining too slowly. The main objectives of the present article are to focus on 1- the current food supply and nutritional status among the vulnerable young population in African countries 2- Insight on the efforts towards reaching the global goal (2) for ending hunger within the context of the SDS2030. The methodology included urgent short- and medium-term interventions priorities programs implemented by foreign aids and international organizations for the management of severe and moderate malnutrition among African children. Details on the composition of the so-called ready-to-use foods used for treating malnourished children are presented. The outcomes of such programs with all their positives and negatives were put together as lessons to be learned and to close the information gap. The cost for treating one single malnourished child with these ready to use foods is in the range between 50 up to 200 US$. To make Goal 2 a reality by the year 2030, a number of scientific-based sustainable solutions were created and recommended for application. Maximizing the use of local food resources, and minimizing losses by applying the logarithm of linear modeling so that nutritious recipes can be formulated at the lowest cost. Capacity building of junior African academics and increased investments in research focusing on diet quality for optimizing the formulation of recipes for feeding infants and children. Strengthening scientific collaboration and exchange of visits and experiences between scientists from the 54 African countries. The establishment of an African Consortium with experts in the diverse areas of food systems to work together more effectively under the umbrella of the African Union.

Keywords: African countries, Staple foods, Intake of animal-sourced foods, Severe and moderately malnourished children, Ready to use foods, SDG 2030, Sustainable nutrient-dense diets, Linear programming, Fermented foods, Intra Africa trade agreements, Political will.

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1 The African continent

The African continent consists of five (5) regions; Eastern (E) , Center or Middle (M), Northern (N), Southern (S) and Western (W) (Figure 1) with population estimates of 449,185,663; 146,728,402; 246,504,780; 101202229 and 396,649,532, respectively totaling 1,129,956,127 billion [1]. The distribution of the population according to the region and the country are also presented in Table (1) showing Nigeria (W) with a population estimate of 206 million to be the largest African country .

2 The staple crops and food commodities

Maize is the staple crop in the majority of the (E), (M) (S) and (W) regions, with daily intakes ranging between < 10 to above 1000 g per capita (Table 1). Rice is a strategic commodity in West Africa with daily per capita consumption ranging between 160 up to > 1000 g (Table 1) and the consumption has grown rapidly over time [2]. It is estimated that cassava is cultivated in around 40 African countries, stretching through a wide belt from Madagascar in the Southeast to Senegal and to Cape Verde in the Northwest. Around 70 percent of Africa's cassava output is harvested in Nigeria, the Congo and Tanzania and the highest intakes were amongst the populations of Conga and Zaire, with an estimated daily intake of close to 1.0 kg of fresh cassava per person per day [approximately 1000 kcal; roughly ½ the estimated daily energy intake]. This rapid spread of cassava cultivation is due to its ease of cultivation and low cost of production. It grows on poor and poorly prepared soils and can stand severe drought and insect attacks, and the roots can remain underground for months without decomposition, even after its leaves have fallen. Some varieties (*Manipeba preta*) allow harvesting more than five years after planting [3]. Wheat is the staple of five (5) Northern African countries with estimated mean daily intakes exceeding 1000 g per capita (Table 1).

3 Animal sourced foods [ASF]

Table (1) presents the daily contributions of milk and fishes to the daily caloric intake are quite low among populations of all African countries [4].

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Table 1: List with the African countries distributed according to region, population, and the daily intakes of total energy, Staple foods, milks, fishes, fruits and proteins

Countries	Population*	Energy	Protein intake g/p/d		Wheat	Rice	Maize	Casava	Milks	Fishes	Fruits
		kcal /p/d	Plant	ASF		g/p/d				kcal /p/d	
Eastern Africa											
Ethiopia	114,963,588	2234	57	6.67	327	43	393	-	59	2	13
Tanzania	59,734,218	2295	49.89	10.48	93	252	563	135	11	25	123
Kenya	53,771,296	2154	47.34	14.65	273	133	688	55	142	15	95
Uganda	45,741,007	2259	41.5	12.5	85	68	390	233	64	54	291
Mozambique	31,255,435	2310	40	8.8	187	235	529	574	31	39	39
Madagascar	27,691,018	1992	35.33	9	98	988	102	228	39	13	59
Malawi	19,129,952	2612	58	8.77	74	44	1089	166	8	30	165
Zambia	18,383,955	2037	45.55	11.31	95	19	1141	38	23	40	12
Somalia	15,893,222	-	-	-	-	-	-	-	-	0	-
Zimbabwe	14,862,924	-	-	-	227	123	882	47	-	0	-
Rwanda	12,952,218	2268	52.07	7,5	130	130	114	289	37	19	430
Burundi	11,890,784	-	-	-	1427	29	127	0	-	0	-
South Sudan	11,193,725	-	-	-	-	-	-	-	-	0	-
Mauritania	4,649,658	2924	52.36	30.74	-	-	-	-	254	39	36
Eritrea	3,546,421	-	-	-	-	-	-	-	-	0	-
Mauritius	1,271,768	3003	46.7	39	923	423	28	0	51	92	59
Djibouti	988,000	2635	52.8	3.86	1001	453	3	1166	86	15	56
Réunion	895,312	-	-	-	-	-	-	-	-	0	-
Mayotte	272,815	-	-	-	-	-	-	-	-	0	-
Seychelles	98,347	-	-	-	-	-	-	-	-	0	-
Middle Africa											
DR Congo	89,561,403	-	-	-	-	-	-	-	-	0	-
Cameroon	26,545,403	2638	56.8	12.7	182	253	393	292	25	55.17	185
Chad	16,425,864	2112	52.8	13.4	40	112	129	44	46	53	15
Congo	5,518,087	2246	28.77	22.9	330	200	31	781	24	94	91
Central African Republic	4,829,767	1820	26.21	20	24	44	176	392	32	23	5
Gabon	2,225,734	2753	41.9	42.9	480	336	123	213	60	123	306
Equatorial Guinea	1,402,985	-	-	-	-	-	-	-	-	0	-
Sao Tome & Principe	219,159	2327	36.65	17.52	422	357	59	17	33	66.9	329
Northern Africa											
Egypt	102,334,404	3378	74.22	24.4	1166	370	582	0	81	82	167
Algeria	43,851,044	-	-	-	1427	29	-	-	-	0	-
Sudan	43,849,260	2438	46.58	22.58	392	22	17	0	243	4	115

Table 2: continuous

Countries	Population*	Energy	Protein intake g/p/d		Wheat	Rice	Maize	Casava	Milks	Fishes	Fruits
		kcal /p/d	Plant	ASF		g/p/d				kcal /p/d	
Morocco	36,910,560	3409	72.44	26	1413	13	312	0	71	69	131
Tunisia	11,818,619	3441	71.16	28.85	1599	12	0	0	181	43	124
Libya	6,871,292	-	-	-	-	-	-	-	-	0	-
W Sahara	869,601	-	-	-	-	-	-	-	-	-	-
Southern Africa											
S. Africa	59,308,690	2980	48.52	35	-	-	-	-	76	24	38
Angola	32,866,272	2246	36.9	21.8	239	90	492	455	29	88	116
Namibia	2,540,905	2282	39	22.82	335	57	362	0	102	41	62
Botswana	2,351,627	2404	36	33.3	383	91	365	0	328	10	29.2
Lesotho	2,142,249	2318	51.25	14.83	138	38	1318	0	43	14	24
Eswatini	1,160,164	2291	41.6	19.2	394	289	622	0	103	17	104
Comoros	832,322	-	-	-	-	-	-	-	-	0	-
Western Africa											
Nigeria	206,139,589	2592	51.83	8.73	-	-	-	-	23	41	73
Ghana	31,072,940	2979	47.22	14.75	234	308	220	688	11	97	350
Ivory Coast	26,378,274	2548	41.2	12.8	216	603	178	304	11	64	151
Niger	24,206,644	2546	67.34	12.45	37	165	34	19	79	10	39
Burkina Faso	20,903,273	2708	66.6	11.33	108	318	670	1	55	13	7
Mali	20,250,833	2833	60.27	22.1	116	571	400	8	196	22	33
Senegal	16,743,927	2465	44	13.4	294	816	267	29	25	57	24
Guinea	13,132,795	2810	50.8	11.19	177	1054	88	290	41	39	155
Benin	12,123,200	2735	51	17.48	120	507	312	341	32	22	43
Togo	8,278,724	2431	51.27	9	128	178	624	318	16	37	11
Sierra-Leone	7,976,983	2475	42.44	14.2	116	1150	18	286	44	87	42
Liberia	5,057,681	2158	28.57	9.94	151	920	2	307	9	25	74
Gambia	2,416,668	2581	61.49	15.75	342	516	131	15	100	82	8
Guinea-Bissau	1,968,001	2149	31.73	9.49	161	986	29	82	42	5	91

FAO Stat 2012, FAO Food Balance Sheet 2020 based on the countries statistical data 2017.

Estimated daily intake of proteins from animal sources from animal protein (foods [ASF] is much lower than that from vegetable sources (Table 1). There is variation between the different African regions in the proportion of children with daily ASF intake. In (N) Africa, 2/3 of the children (up to 24 months) consume a source of dairy product once daily versus 1/5 of the respective children in the (E) and (W) African regions [5]. With respect to the daily intake of fishes, 21 and 31 % of the children from The overall daily protein intake among €) and (W) African regions were consuming fishes once daily, versus 7 % of the children from the (N) African region (Figure 2). In Nigeria, the estimated daily intake of fish amounts to 9.92 g equivalent to almost 50 % of the total ASF [6].

Figure 1 illustrates the percentage of children (Up to 24 months) consuming daily any of 5 different ASF. Figure (3) illustrates the percentage of children from the 3 main African regions consuming daily one, two or three ASR.

In the ECOWAS region, which consists of 15 (W) African countries with a total population estimate of 319,817,414 million belonging to 15 Western African countries, milk and meat production were estimated to be about 4. 05 million and 1.84 million tonnes respectively [7]. Local livestock breeds have adapted to the inadequate rainfall and high evaporation rates and have a higher resistance to local pests and diseases, also have a lower carbon and water footprint than many international breeds

dominating global livestock production. Every year thousands of tonnes of imported milk products and powder are processed into various products through the ECOWAS zone. The estimated annual per capita consumption of animal products in Sub-Saharan Africa [2005] amounted to 13.3 kg for meat, 30.1kg for milk, and 1.6 kg for eggs [8]. Available information did not allow for a quantification of intra-regional flows of meat, or of live animals that are usually traded between Sahelian [Burkina Faso, Mali and Niger] and coastal countries that have a deficit in meat production, or of the imported frozen meat from Europe, and Latina America. The main components of the poultry sector in Africa are the family and rural sectors which make around 80% of poultry stocks in many African countries. The smallholder production is mainly free-range systems and women are the caretakers and decision-makers of most chicken flocks, and chicken meat is eaten more than any other meat. During the last two decades of the 20th century, massive investments were made in the Northern African countries; Morocco, Algeria and Egypt for the development of environmentally controlled poultry houses equipped with evaporative cooling systems and over 22 billion table eggs annual production, which, account for over 2.5% of the total world production of table eggs [9]. The top egg-producing countries of Africa [Nigeria, South Africa, Egypt, Morocco, and Algeria] have increased their production to 1,857 thousand tonnes in 2009. Moroccan industry had undergone tremendous growth and in 2009, per capita consumption in Morocco was 98 eggs and 17.3 kg of poultry meat [10] and in Egypt the respective per capita consumptions were 63 eggs and 10 kg of poultry meat[11].

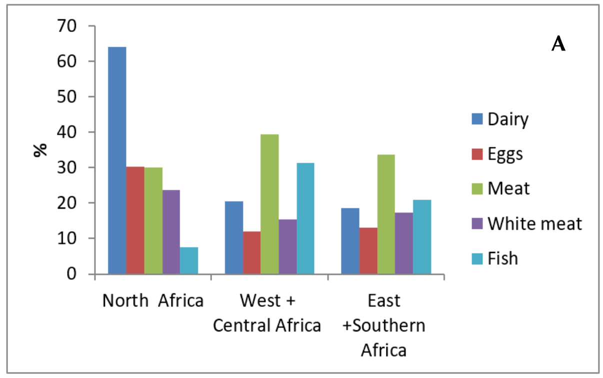
Data in FBS are estimated on the food availability of food that means the sum of the production plus import divided by the number of population. FBS has been criticized for being indirect and is unable to pinpoint the "hunger hot spots. Direct measurement of undernutrition among the overall population, can offer a relatively reliable basis and indicator for estimating undernutrition among children. Undernutrition among the 10–15 year age group was assumed to be the same as those in the 15–20 segment [12].

4 Dietary energy

The daily calorie intake of 2100 kilocalories per person per day is the cut-off point for food poverty line at household level [13]. According to this definition, the populations of Madagascar, Zambia and Central African Republic (Table 1) with estimated daily energy intake less than 2100 kilocalories may be at risk of food poverty line. The data presented in Table (1) are based on the Food Balance Sheets (FBS) of each respective country for the year 2017 [4].

5 Prevalence of malnutrition using indicators for child anthropometry

A healthy child should weigh 10 kilograms with a body length of 77 cm at the 15 months of age [14]. Children malnutrition is a leading cause of preventable death in Africa and about 50 million children less than 5 years are wasted (too thin); of these, between



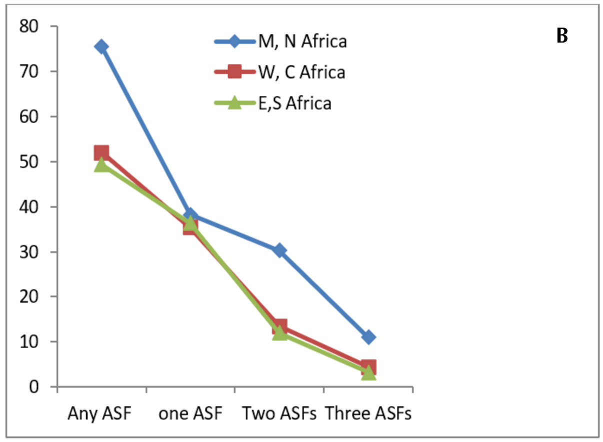


Figure 1: Percentage of African children A: distributed according to regions according to daily consumption of the ASF; B: (Up to 24 months of age) consuming one, two or three portions of ASF [Modified from data reported by [5]]

17 - 20 million are severely wasted and in need of treatment. Moderate acute malnutrition [MAM] is defined as a weight-for-height z-score (WHZ) between - 2 and - 3 [15].

Stunting (low height-for-age) is an important indicator of chronic undernutrition affecting 36.7; 32.5, 17.5; 28.1 and 31.4 % of the African children under 5 years from (E, (M), (N), (S) and (W) regions, respectively [15].

The Threshold for stunting among children in a country is set up at 15%, if the prevalence since low birthweight is more common among infants whose mothers and even grandmothers were stunted during early childhood [16].

In addition, childhood stunting is estimated to deliver a per capita income penalty of 9–10% of gross domestic product (GDP) in Sub-Saharan Africa [17]. Prevalences exceed this threshold, it indicates the need for national and international intervention. Stunting begins in utero and is greatest during the first 1000 days of life, from conception to age 2 years [16], though the adverse effects persist for many more years later. This means that the first 1000 days post-conception is a critical time for proper nutrition for the mother and child [19].

In the long term, chronic malnutrition reduces cognitive and physical development, increases rates of sickness and death from

common illnesses, and reduces educational outcomes and lifelong productive capacity [20]. This combination of metabolic changes and nutrient deficiencies in infancy may lead to poorer health later in life, resulting in adults with increased risk of non-communicable diseases such as hypertension, cardiovascular disease, and Type 2 diabetes, compared to those who are not stunted [21]. Stunting also has intergenerational effects since low birthweight is more common among infants whose mothers and even grandmothers were stunted during early childhood [22]. In addition, childhood stunting is estimated to deliver a per capita income penalty of 9–10% of gross domestic product (GDP) in Sub-Saharan Africa [19]. Prevalences of 36.34, 12.09 and 24.87% were reported for stunting, wasting and underweight, respectively among Ethiopian children under 5 years; two indicators exceed the 15 % threshold. Indicates the urgent need for national intervention[22] and the authors emphasized that the three undernutrition indicators should be considered simultaneously because they are not redundant of each other. Prevalences of child malnutrition were reported for children belonging to 32 Sub-Saharan African countries, and the authors concluded that the highest prevalences were reported in children living in (E) African region (Table 2).

The lack of high-quality protein in the diets of young children is a potential cause of stunting [23]. A recent analysis of 130,432 children aged 6–23 months from 49 countries reported a strong negative association between the intake of ASF such as dairy, meat/fish, and egg and child stunting [24]. These findings support the scientific-based evidence on the superiority of ASF over the plant-sourced foods [peanuts / corn soybean blends] on growth. This implies increased investments in research focusing on diet quality for the fragile infant digestive systems and linking the increased intake of ASF by preschool children to reducing the prevalence of stunting [24].

Table 2: Sub-Saharan countries with highest % prevalence of stunting, wasting and unweight children under 5 years [18]

Eastern Region		Middle Region		Southern Region		Western Region	
Stunting %							
Country	**Prevalence**	**Country**	**Prevalence**	**Country**	**Prevalence**	**Country**	**Prevalence**
Burundi	57.7	DR Congo	42.7	-	-	Niger	43.9
Malawi	47.1	Chad	39.9	-	-	Mali	38.3
						Sierra Leone	37.9
						Nigeria	36.8
Wasting %							
Comoros	11.1	Chad	13	Namibia	6.2	Niger	18
Ethiopia	8.7	S. Tomes	10.5	-	-	Burkina Faso	15.5
						Mali	12.7
Underweight %							
Burundi	28.8	Chad	28.8	-	-	Niger	36.4
Ethiopia	25.2		10.5	-	-	Nigeria	28.7
						Burkina Faso	25.7
						Mali	25

TEI: total energy intake

6 Nutrition strategies for ending hunger and malnutrition

Numerous nutritional programs have attempted to improve nutritional outcomes, but with mixed success due to lack of sustainability and different factors as indicated below.

6.1 The Ready-to-use therapeutic foods [RUTF]

The RUTF BP-100 developed in the 1980s is a nutrient- and energy-dense milk powder supplying 50% of overall protein fortified with sugar, vitamins and minerals [25] (Table 3). RUTF are high-energy, fortified, ready-to-eat foods suitable for the treatment of children with severe acute malnutrition. These foods should be soft or crushable and should be easy for young children to eat without any preparation. At least half of the proteins contained in the foods should come from milk products. The dry powder with maximum moisture of 2.5 % does not support bacterial growth due to its low water activity and the powder needs to be reconstituted with clean potable drinking water, energy to heat it, clean utensils and a highly precise mix which, once made, only retains its properties for a few hours. The solution spoils and may absorb bacteria that cause infectious diseases and this implies that it generally needs to be administered only through inpatient nutrition centers where children need to stay for around one month, usually with their mothers, who leave their home and

work and put other children at risk. The problem is that hospital capacities are limited and crowded hospitals also multiply the risk of epidemics caused by infectious diseases. Effective treatment of children with SAM can also be achieved at home, via community-based management of severe acute malnutrition (CMAM), which greatly reduces cost, allowing an increased coverage and reduces the burden on in-patient health care facilities[25].

Table 3: Nutritional composition of the standard RUTF- BP-100 [Nutrition fact - Manufacturer Compact Co -Søfteland, Norway]

Nutrients	RUTF P 100	UN requirements
Energy, kcal	529	525- 550
Protein/ total energy, %	11.1	10 - 12
Fat/total energy, %	51.6	45 - 60
Omega 6 / total energy , %		3 - 10
Omega 3/ total energy, %		0.3 – 2.5
Vitamin A, mg	0.9	0.8-1.1
Vitamin E, mg	27	≥ 20
Vitamin B1, mg	0.5	≥ 0.5
Vitamin B2, mg	1.8	≥ 1.6
Vitamin C, mg	54	≥ 50
Vitamin B6, mg	0.7	≥ 0.6
Vitamin B12, µg	1.6	≥ 1.6
Folic acid, µg	225	≥ 200
Niacin, mg	5.8	≥ 5.0
Calcium, mg	470	300 - 600
Phosphorus, mg	470	300 - 600
Sodium, mg	< 290	≤ 290
Potassium, mg	1100	1100 - 1400
Magnesium, mg	110	80 – 140
Iron, mg	10	10 - 14
Zinc, mg	12.0	11 - 14
Iodine, µg	110.0	70–140
Selenium, µg	25	20 - 40

Data are expressed as mean ± SD; SBP: Systolic blood pressure; DBP: diastolic blood pressure.

The use of RUTF by UNICEF (the largest user) increased from 200,000 cartons for 27 countries in 2006 to over 1.2 million cartons for 50 countries in 2010. Fifty percent of the 2010 purchases came from Nutriset, a French company, which produces therapeutic milk F100 for hospital-based treatment of SAM. RUTF is a product not likely to be abused through promotion to the public on the open market because it is bought mainly by UNICEF and NGOs that work with CMAM. By 2011, 1.1 million cases with uncomplicated SAM in Congo and 1.6 million in Nigeria were treated with RUTF and the product is attractive to donor agencies because of its great shelf-life stability and reduced burden on local in-patient health care facilities. Proof of the advantages of RUTF BP100 s is due to its high milk content and its high acceptability by the sick children resulting in an average 51% higher recovery rate and in preventing relapse than standard care; though weight gain differences between groups in controlled trials were small [26].

Table 4: Nutritional composition of the standard RUTF- BP-100 [Nutrition fact - Manufacturer Compact Co -Søfteland, Norway]

Nutrients	RUTF P 100	UN requirements
Energy, kcal	529	525- 550
Protein/ total energy, %	11.1	10 - 12
Fat/total energy, %	51.6	45 - 60
Omega 6 / total energy , %		3 - 10
Omega 3/ total energy, %		0.3 – 2.5
Vitamin A, mg	0.9	0.8-1.1
Vitamin E, mg	27	≥ 20
Vitamin B1, mg	0.5	≥ 0.5

Case fatality rates tended to be well under 10% in CMAM programs. The success rates of SAM cases including edema (the so-called kwashiorkor variety) were often not high, and poor-quality data were available for treatment. One of the drawbacks of RUTF is its high renal solute load, which requires that the child has to drink extra water when eating it. Also, the high sugar content of RUTF BP100 may also mislead families, encouraging increased consumption of sweet foods with low nutrient density. Increasing the scale of production has failed to bring down the unit cost of RUTF and today, the production and distribution of RUTF BP100 are reduced to about 1/3 of the respective 2003 level. The provision of RUTH depends often on CMAM funded via humanitarian or emergency funding, which by definition means it is short-term program, not integrated into government programming. Even the few governments that have budgets for it, these cover only 15-20% of the cases. The high content of milk powder is the most expensive ingredient of RUTF BP100. Formulations with reduced milk protein with sources including whey protein are amongst the options addressed by WHO to reduce the cost and enable more children with acute malnutrition to be treated and thus improving coverage. The product BP100 is monopolized by a handful of manufacturers able to put in place strict quality control measures and UNICEF requires that the vitamins and minerals premix must be obtained from the European companies: Piramal Group, DSM Nutrition/Fortitech, Hexagon Nutrition, the GAIN premix facility, BASF [27]. Other problems associated with the use of RUTF, if the health care systems are weak, with inadequate access to effective remedies malnourished children will die, even if RUTF is available. The positive and negative aspects of the RUTH had been addressed by Codex Alimentarius [28] and it was concluded that clinical evidence should be considered before recommending any changes to the formulation of RUTF. The product will not contribute to teaching the child to like the taste of the healthy local foods needed to avoid malnutrition in the future. Increased use of ready-to-use and "specially formulated foods" will result in changing nutrition behaviors and nutritional support from whole local foods provided to families in a negative direction. Giving an industrially packaged foil-wrapped food product (a magic bullet) is not responsible public health practice, while enabling supportive counseling on nutrition, coordinated with services available locally should be the appropriate correct sustainable and long-term approach.

Homemade energy- and protein-dense food mixtures are probably the best delivery system for community-based care, whereas, ready-use therapeutic foods may be an alternative, if carers cannot make such foods. Efforts are being undertaken to modify the RUTF recipe so that more locally available ingredients are used and costs are lower [29]. From the nutritional physiological point of view, some modifications should be introduced during the processing technology of RUTF, given the high price of the product. The price of the present RUTF is unnecessarily expensive and curing a child of SAM costs 70-200 US $; 50 % of which is for the RUTF product itself, homemade nutritious foods are most cost-effective. It is now agreed upon that imported or local RUTF should only be fed to children when local family foods are scarce or impossible and it should only be used for children with SAM who have an appetite and are without medical complications, until they are discharged then they should be put on augmented local/family foods.

6.2 Ready to use supplementary food [RUSF]

Supplementary feeding means providing extra food to people over and above their home diet and has been given in combination with vitamins or minerals to vulnerable groups that are food insecure over different periods. The intention of complementary foods added at 6 months of age is to maintain breastmilk production, while giving additional food as the child continues to grow. In the mid-1990s, a nutrition expert with long experience in low-income settings formulated ready to eat Plumpy'Nut® [PN] product based on peanut paste [Table 5,6]. The ready-made nutrient blend has a low water activity (<2.5%) that bacteria cannot thrive in it, even without refrigeration for an extended period. The license of Plumpy'Nut® [PN] is monopolized by Nutriset in a dozen developing countries for establishing the companies and producing the product. In 2010, Nutriset company faced lawsuits and bad publicity and accordingly today several other companies produced local versions of RUSF products independently of Nutriset and appear to function well. Plumpy'Nut® is served in the treatment of SAM for stunted children over 2 years of age and the product was tested for large-scale use to prevent moderate acute malnutrition [MAM] from developing into severe acute malnutrition [SAM] or for replacing cereal blends used in food aid programs. Being less expensive than RUTFs BP100, The cost for an 8-week treatment of Plumpy'Nut® for one child is around $50. RUSFs Plumpy'Nut® are attractive because they have the advantage of being a nutritious infant formula with relatively higher energy content providing milk powder (or whey protein), easily and safely stored with longer shelf life, that is and resistant to bacterial contamination and providing nutrients like iron and zinc that are difficult for low-income families to provide the inadequate quantity to infants starting at 6 months of life.

Second, RUSFs is a convenient vehicle in a way that saves mothers' time because successful use of home-made complementary foods is time-consuming with difficulty keeping a number of children healthy for some mothers who are working 12 hours a day just to afford tomorrow's food.

Table 5: Composition of a daily dose (46 g) of RUSF and MNP formulation

Ingredients	Amount consumed
Weight of daily RUSF	46
Energy, kcal	247
Protein, g	5.9
Lipids, g	16
Linoleic acid, g	2.0
α–linoleic acid, g	0.3
Vitamin A, μg	400
Vitamin E, mg	6.0
Thiamine, mg	0.5
Niacin, mg	6.0
Pantothenic acid, mg	2.0
Vitamin B6, mg	0.5
Folic acid, μg	160
Vitamin B12, μg	0.9
Vitamin C, mg	30
Calcium, mg	387
Magnesium, mg	60
Iron, mg	9.0
Zinc	4.0
Potassium, mg	310
Phosphorus, mg	275
Iodine, μg	90
Selenium, μg	17
Manganese, mg	0.17
Copper, mg	0.3
MNP Formulation	
Vitamin/ Mineral	**Amount per sachet**
Vitamin A μg	400
Vitamin D μg	5
Tocopherol equivalents mg	5
Thiamine mg	0.5
Riboflavin mg	0.5
Vitamin B6 mg	0.5
Folic acid μg	90
Niacin mg	6
Vitamin B12 μg	0.9
Vitamin C mg	30
Copper mg	0.56
Iodine μg	90
Selenium μg	17
Zinc mg	4.1
Na-Fe-EDTA mg	12.5 or 30

RUSFs are designed to avoid some of the limitations in absorbability and some of the anti-nutritional substances present not only in home-made foods but in many foods used in food aid for supplemental feeding such as corn soy blend (often distributed together with vegetable oil). The duration of use, the amount given per day and delivery costs all need to be taken into account.

The daily supplementation of staple foods eaten by 1,038 Chad children aged 6 to 36 months with 46 g RUSF at the end of the 4 months duration of the intervention trial to a modestly higher gain in height-for-age and significantly higher hemoglobin concentration than the control group, thereby reducing the odds of anemia by almost 50% and a significantly lower risk of self reported diarrhea (–29.3%) and fever episodes (–22.5%) [30].

however, adding RUSF did not result in a reduction in the cumulative incidence of wasting. The presence of zinc in RUSF was the responsible factor for the positive effects on linear growth, blood hemoglobin concentration and on lowering morbidity [30], but failed to prevent acute malnutrition among Mali children. The daily consumption of 50 g Plumpy'Nut® for one whole year was associated with improvement in the growth of children.

The gain in body weight of Mali children (6 – 36 months old), who were fed daily RUSF to provide 500 kcal gain was RUSF was higher after 12 weeks of the intervention compared with the respective group on homemade RUSF [31]. Due to the high cost of treatment with RUSF, the authors pointed out that the benefits of treatment should be considered in relation to product's costs and availability.

Monitoring and following a set of guidelines and criteria such as children's height to decide which children to be provided by Plumpy'Nut® managed to lower the costs by 61 % for food aid delivered by the World Food Program. Practically, when 20-30 million children are suffering from SAM, causing perhaps a million deaths a year [5 % fatality]; there are still another 90% vulnerable children suffering from different morbidities other than SAM; which could not be treated with RUSFs and those vulnerable children are in danger because they are receiving less attention. CMAM reports are now stating that stunting cannot be successfully addressed without first solving the problem of wasting.

Donors consider CMAM projects, as if the use of RUSFs can prevent malnutrition or replace complementary feeding, and could include literally billions of children suffering from hunger and malnutrition problems. Plumpy'Nut® like BP100 are not sustainable and can only be a minor part of the solution to undernutrition. As far as effectiveness is concerned, PN may increase recovery rates and decrease non-responders in treating MAM, but weight gain differences between groups in controlled trials are small. Also, they have no proven benefits over other supplements in preventing under-nutrition.

The relatively high cost of milk powder, make RUSF a relatively expensive product. A cheaper RUTF formulation, containing whey protein concentrate (WPC) instead of the ordinary dried skimmed milk (DSM) was comparable to the DSM RUTF in terms of rate of recovery from SAM, average weight gain and length of stay in the treatment program [32]. The supply of Plumpy'Nut® alongside staple rations to children aged 6-36 months who were not acutely malnourished failed to reduce wasting rates compared to the group on the staple rations [33]. Cost-effectiveness analysis on the successful secondary outcomes of cases of diarrhea and anemia showed that adding PN was less cost-effective than other standard intervention options for averting diarrhea and anemia , since incremental cost per episode of diarrhea averted of 1,083 Euros and per case of anemia averted of 3,627 Euros [33].

The downsides of RUSF Plumpy'Nut® are new foods, unfamiliar to the populations and their long-term effects on body composition are unknown. The presence of 25 – 30 % peanuts in RUSF the food most commonly contaminated with aflatoxin, the known hepatic carcinogen [34,35] requires high standard quality control measures, which makes the use of this low-cost food at risk of being contaminated also with *Cronobacter sakazakii*. Like BP 100, PN requires access to extra safe water for infants and young children and their packages have to be transported over long distances and create additional waste requiring disposal. They do not contribute to teaching the child to like the taste of the healthy local foods needed to avoid malnutrition in the future. There is concern that its high calories could displace the greater chance for breastfeeding. The scientific evidence base for RUSF and even for RUTF is so weak, the differences were for the most part small and conflicts of interest are involved in setting up both political and economic agendas.

6.2.1 Marketing for RUSF products and the threat for breast milk feeding

In 2008, UNICEF was promoting the use of RUSF Plumpy to prevent malnutrition or treat MAM in Somalia, an initiative that was not in response to any request or demand from the developing countries themselves. The programs of CMAM are donor-driven approaches, and could compete with rush toward RUTF and RUSF products, bypassing governments to a large extent for prioritizing investment options. The majority of financing of CMAM is covered under the humanitarian budgets that are available only for short periods of time to cover costs during emergencies and can rapidly disappear when more severe emergencies occur elsewhere. As a consequence, just one month after introducing complementary foods to 6 month-old breast-fed infants, their daily milk intake from their lactating mothers declined significantly from 129 down to 115 g/kg body weight [36]. The medicalizing and commercializing of RUTF/ RUSF for the treatment of millions of children with mild malnutrition or chronic hunger is unrealistic and irresponsible thinking because Guidelines are needed to give equal weights to reach the optimum local measures to improve food intakes, health services and child care from one side and the appropriate use of fortified commercial foods supplements. The RUSF should not be used as a preventive measure in stable populations and should be prepared from locally-produced foods to the greatest extent possible and not imported and without undue commercial influence [37].

6.3 Lipid nutrient supplements [LNS]

Much of the thinking and research on the development of lipid-based nutrient supplements (LNS) is being done by a group from the University of California- Davis. The LNS are sweet fortified lipid-based spreads with reduced bulk, containing peanut paste, milk powder, vegetable oil, sugar and different concentrations of premade micronutrient mixture and is a product of Nutriset, Malaunay, France. Few international organizations distributed lipid-based supplements such as Plumpy, peanut paste, Plumpy'Nut®, Peanut Butter on Malawian children with a rough maximum estimate of 50000 child per year. The composition and the effectiveness and safety of LNS for the treatment of MAM in infants and children 6 to 59 months of age had been reviewed and the results showed that it has no impact on mortality rate, but is slightly more effective than specially formulated fortified foods in recovery of African children from MAM, lowering the risk of

deterioration into SAM, and improving weight gain [38]. Few reports claimed that the LNS induced vomiting at a higher rate. At least 50 g/d LNS providing 264 kcal for a whole year was required for a positive and sustained impact on the incidence of severe stunting in rural Malawian infants 6 – 18 months of age, while infants receiving 25 g daily for the same period of time didn't show positive response [39]. The USAID donation consists of Corn Soy Blend (CSB) grown by the American farmers and imported to Africa to be alternative to LNS in treating Malawian children with moderate malnutrition [40]. The 200 g corn–soy blend (1:1 w/w) + 20 g sugar + 20 g of fortified vegetable oil (the fortification is not specified) provides approximately 1,000 kcal/day. This 1,000 kcal daily energy intake is excessively high for many moderately wasted children 12 to 15 months of age, whose average body weight is roughly 7.0 kg with a weight gain target of 5 g/kg/day are so that the CSB should not provide more than 770 kcal/day, when it is taken into account that many children also receive breast milk. Estimated cost for treating MAS children with the American corn soybean blend is estimated to be 143 US$ per treated beneficiary [40]. Different formulations were described in the literature based on blends of maize, sorghum and soya containing milk or free of milk and their effectiveness were tested on Congolian children in the age group 12 – 23 and 24–59 months, the milk peanut RUSF was superior in the recovery of young children [32,41].

6.4 Micronutrient powders [MNP]

Anemia is estimated to be 62.3 % among African preschool children 1 – 5 years old [42]; approximately 50% is attributable to iron deficiency anemia (IDA) [43] and it is assumed to be higher (about 60%) in malaria-free areas [44]. IDA is a condition characterized by a reduction in the body's oxygen-carrying capacity and is of particular concern during infancy, as iron requirements are relatively high during periods of rapid growth. In young children, peak prevalence of IDA occurs around 18 months, and then falls, as iron requirements decline and iron intake is increased through complementary foods. Iron deficiency during early childhood is associated with impaired motor and mental development, poorer socio-emotional behavior, and reduced school achievement [45]. Because of these negative consequences, IDA is estimated to be the leading cause of years lived with disability among children [46]. Anemia in children is diagnosed when the hemoglobin (Hb) concentration in the blood is below a predefined cut-off value [< 11.0 g/dl]. Besides iron, other essential micronutrients such as vitamin A, iodine, zinc, and other micronutrients are also deficient in young [47]. Meeting the micronutrient needs include prevention of parasitic infestations; dietary diversification to improve the consumption of foods with highly absorbable vitamins and minerals; provision of supplementary foods; and provision of supplements in the form of liquids, micronutrient powder with the latter being a widespread intervention [48], Anemia in children 6–23 months of age is critical, because it is usually difficult to ensure an adequate quantity and quality of complementary foods containing micronutrients dense diet to meet these requirements within the limited volume of food children consume [49-51]. Micronutrient powder [MNP] is a mixture containing between 5 and 15 encapsulated minerals and vitamins that are packaged in small sachets [Table 5], which are stirred into a child's portion of base' diet immediately before consumption, making it possible to provide the appropriate amounts of micronutrients needed by each age subgroup (e.g. 6–12 months, 12–23 months) without the need to make major changes in dietary practices. The use of MNP containing iron, vitamin A, and zinc with or without other micronutrients had been recommended to achieve 100% of the recommended nutrient intake for children 6–23 months of age and more recently has expanded its use in children 2–12 years of age [52]. MNP program is defined as being at national scale when the eligible poorest 20% of the population is reached with long-term delivery The dose of 12.5 mg of elemental iron (as ferrous fumarate) along with 5 mg of zinc and 300µg of vitamin A has proven effective and the addition of other vitamins and minerals could be considered within the recommended nutrient intake levels for this age group. Several studies concluded that MMN supplementation in young children improved micronutrient status and had modest effects on linear growth [53]. The results of 11 trials with overall 2746 children who received iron-containing MNP for point-of-use fortification of foods for a duration of 2 – 12 months showed a significant increase in the blood hemoglobin concentration by a mean difference of 3.37 g/L, compared with those, who did not receive intervention [54]. Based on 13 studies covering 5810 participants from Asia and Africa, the authors concluded that point of use fortification of foods with MNPs containing iron reduces anemia and iron deficiency in preschool and school age children but information on mortality, morbidity, developmental outcomes and adverse effects is still scarce [55].

Beyond its efficacy in reducing anemia, there is no adequate information on its impact on mortality, morbidity, developmental outcomes; though there is some evidence that MNP may reduce vitamin A deficiency [56] and stunting [57]. MNP can be produced in large quantities at a relatively low cost and the total estimated cost of implementing sustainable MNP interventions is $7.20 per child per year equivalent to 0.02$ per sachet for supply and delivery [58,59]. A wide variety of experiences implementing micronutrient powders exist, but there is no one size fits all approach and MNP interventions have had mixed success [60].

A guideline was published for the use of multiple micronutrient powders for the point-of-use fortification of foods consumed by infants, young children and preadolescents [52]. Experiences from various countries cite MNP discoloration, odors, and other quality issues that have had a negative effect on program outcomes, particularly around acceptability of the product [61]. MNP is procured through global pre-approved suppliers to meet the specification and quality requirements of MNP and challenges remain around the importance of high-quality MNP products. Lengthy procurement lead times are associated with loss of product and inflexibility in package design. Weak monitoring systems do not provide reliable data on negative and positive factors affecting MNP program implementation [29] and most existing documentation focuses on acceptability trials with the lack of published or documented experience, particularly from larger or scaled MNP interventions [62]. Better evaluation processes

are needed to consider adherence and appropriate use and action-oriented research in the area of nutrition are known [63,64].

6.4.1 Adverse effect of MNP on the gut microbiota of African children

Colonic microbiota can contribute to energy production, activating the immune system and low levels of inflammation, but their composition and function are easily manipulated by dietary changes. Iron is a growth-limiting nutrient for many gut bacteria, therefore the current daily iron dose (12.5 mg/day) in MNP was reported to increase enteropathogens, diarrhea and respiratory tract infections (RTIs) and to decrease gut beneficial bacteria *Bifidobacteriaceae* and *Lactobacillaceae* both in infancy [65] and in childhood [66]. The iron doses varied from 12.5 mg to 30 mg of elemental iron and are in the form of chelated ferrous sulfate; microencapsulated ferrous fumarate or sodium iron ethylenediaminetetraacetic acid (Na-Fe-EDTA). Iron absorption from MNPs by African infants is only 4%–9%; thus, most of the iron passes unabsorbed into the infant's colon.

An intervention study was carried out on Ivorian children 6-14-y-old (n = 139) using iron-fortified biscuits, which contained 20 mg Fe/d, 4 times/week as electrolytic iron [66]. After 6 months, the duration of the intervention, the results show that iron fortification was ineffective and didn't change iron status, anemia, or hookworm prevalence, but the fecal microbiota was modified with a significant increase in the number of pathogenic enterobacteria ($P<0.005$) and a decrease in the beneficial lactobacilli ($P<0.0001$), compared with the control group [66]. In addition the iron fortification for 6 months significantly increased the fecal concentration [calprotectin] the biomarker of gut inflammation which correlated with the increase in the fecal pathogenic enterobacteria. Accordingly, the authors concluded that iron fortification in this population produces a potentially more pathogenic gut microbiota profile, which is associated with increased gut inflammation.

Accordingly, MNP preparation containing a 5 mg daily dose of highly bioavailable iron was formulated and when fed to Kenyan infants 6.5 – 9.5 months for four months [65]. The results showed that the low iron dose-maintained efficacy, and reduced the adverse effects of iron on the infant gut microbiome changes. The authors recommended the addition of 7.5 grams of the prebiotic galactooligosaccharides (GOS) to offset the adverse effects of iron on the infant's gut and to selectively enhance the growth of *Bifidobacteriaceae* and *Lactobacillaceae* [65]. Such an addition will certainly add to the final cost of the product.

7 Zero hunger Goal (2) of the UN Sustainable Development Goals SDG 2030

In 2015 leaders from 193 countries created the SDGs 2030[67] with 17 goals and 169 targets, which are considered a road map setting agenda that every country is meant to achieve a better and more sustainable future for everyone [68]. Ending hunger, and malnutrition; goal (2) of the SDG 2030 consists of five indicators (Figure 4). The present article addressed only indicators 3 and 4 of relevance to reducing stunting and wasting by 50 % among children under 5 years of age to achieve maximum growth velocity and development to its maximum potential.

By 2030, zero hunger ensures access to safe, nutritious and sufficient food all year round by all people, in particular poor infants and children in vulnerable situations. The ideal diet is one that is healthy, of sufficient quality and quantity, affordable, safe and culturally acceptable for human ideal nutrition and health status [69]. All forms of malnutrition, including stunting and wasting in children under 5 years of age, and the nutritional needs of adolescent girls, pregnant and lactating women and older persons will be taken care of. Zero hunger and malnutrition is a multisectoral approach focusing primarily on ensuring food supply stability and access to adequate health and promote dietary shifts that assure adequate growth and development of African children.

7.1 Sustainable diet by incorporating ASF

Food-Based Dietary Guidelines (FBDGs) are developed to promote healthier eating patterns and the Food Pyramids for Children (Figure 5) is an excellent application of the FBDG. The concept of sustainable diets and food systems was developed[70,71]. Sustainable diets are those that promote environmental and economic stability through low-impact and affordable foods, optimize nutritional status, growth velocity and development to its maximum potential. A nutrient-rich foods approach (aiming at quality, not just quantity), and facilitating dietary diversity could be valuable and nutrient profiling of foods or ranking foods based on their nutrient composition has received ample interest globally [72]. Choosing nutrient-dense "nutrient-rich" foods will remain the sustainable foundation of public health guidance, since they are culturally acceptable, will not change food consumption patterns of the communities, and will contribute to promoting the overall health status. Better standardized measurements and indicators are needed for the periodic assessment and monitoring the impact of the various determinants of sustainable diets on different outcomes of health such as: change in body composition; cognitive function, motor performance, micronutrient and immunity status [73].

7.2 Cost-effectiveness of ASF supplements over corn-soybean –oil RUSF

The protein quality of ASFs (meat, poultry, fish and eggs) is high[74,75] with percentage digestibility exceeding 90 % [76]. The proteins of ASF contain optimum essential amino acid (EAA) profiles, in particular the S-contg amino acid methionine, compared to the respective profile in plant-based proteins (Table 5). Methionine is the limiting amino acid in peanuts, and would provide only 35% of the FAO/WHO requirements [77]. Methionine is especially important for African children, who ingest cassava as part of their staple diet. Cassava contains a substantial amount of cyanogenic glucosides [50 mg / kilogram fresh cassava root] [78], which exert intoxication after ingestion of cassava. Adequate intake of methionine potentially detoxifies the toxic action of hydrocyanide radical (HCN), by sulfuration to its

respective sodium thiocyanate (NaSCN) metabolite, which is excreted in the urine as thiocyanate (SCN) [79].

Animal products are energy-dense and contain multiple micronutrients linked to growth and cognitive development (particularly iron, zinc, vitamin A, vitamin B12, and choline) and essential fatty acids in a highly bioavailable form and their consumption is associated with improved growth and developmental outcomes in observational studies [80].

Cow's milk is uniquely rich in calcium and its ability to stimulate the secretion of insulin-like growth factor I (IGF-I), a hormone that stimulates bone and tissue growth [81]. Animal proteins activate the mechanistic target of rapamycin complex 1(mTORC1), which regulates growth in chondral plates (i.e., part of the bone where growth takes place) and in skeletal muscle growth. ASF provide not only calories and high-quality proteins but, more importantly, the nutrients required for the achievement of human development potential [82]. Animal source foods (ASF) generally contain more bioavailable iron than plant foods, and consuming ASF with plant-based foods increases the absorption of iron in the latter. Consuming fish with vegetables increases the absorption of vitamin A and some fish species contain twice as high vitamin A concentration of vegetables as carrots or spinach[81,82]. In addition, ASF are the only natural source of vitamin B12. Deficiencies of nutrients that are critical for neurological development and present in ASF (vitamin B12, vitamin A, iron, zinc, docosahexaenoic acid, and iodine) have been associated with brain-related disorders, including low intelligence quotient [83]. South African children 7 -9 years old receiving daily 25 g fish-flour spread on a piece of bread for 6 months improved the verbal learning ability and memory of the children [84]. Supplementation of basal diets of Kenyan schoolchildren with small amounts of meat or milk increased their test scores by 45 and 28%, respectively [84]. Meat supplementation was associated with increased cognitive skills, leadership behavior, physical activity, and initiative [85]. Based on their composition of micro- and macronutrients, as well as essential amino acids, increasing ASF consumption is likely to be more effective at reducing stunting than single nutrient supplementation [82].

Being aware of the high prices of ASF, the application of simple food technologies processes can potentially produce nutrient-dense fried bars based on the blend from homogenates of whole small fishes and underutilized offal mixed in different proportions with the staple foods and grated leafy vegetables and deep-fried in oil to be served as balls or bars, with extended shelf life. Such products will assure food diversification and will be accepted at the community level. Women at the locality can be trained on how to prepare such products for marketing at the community level.

7.3 Traditional fermented foods

A report highlighted the most important traditional fermented foods in the culture of some African countries and emphasized their impact on overall health [86]. Fermentation provides a natural way to reduce the volume of the material to be transported, to destroys undesirable components, enhances the nutritive value and appearance of the food, and reduces the energy required for cooking. Fermented cereal foods offer (W) African consumers an affordable source of food and make a significant contribution to their food and nutritional security. In Côte d'Ivoire, baca or wômi is a traditional fermented food commonly consumed by the community and is prepared from cereals such as maize, rice, millet inoculated with mixed beneficial probiotic lactic acid bacteria strains; pumpkin (17 %) and moringa leaves powder (7 %). The dough is left at ambient temperature for 24 hours for fermentation followed by 3 day of solar drying [Soro, 2014]. Serving this home preparation to moderately wasted Ugandan children aged 7-36 months for 4 months results in good recovery [87]. Eleven lactic acid bacteria [LAB] cereal-based fermented foods are recently listed, which are commonly consumed in (E), (S) and (W) African regions [88] and their use accounts for up to 80% of total calorie consumption in many households [89]. The viable LAB in these fermented products had antibacterial activities and with potential antidiarrheal action [90]. Like other fermented cereal foods available in the region, these products suffer from inconsistent quality. With increasing urbanization, efforts are currently geared towards developing small-scale facilities for producing fermented cereal foods where the quality of the finished product will be assured. The development and improvement of inoculants containing high concentrations of live microorganisms, referred to as starter cultures, is a subject of increasing interest in efforts to standardize the fermentation step and the use of dried starter cultures [91]. In order to provide West African consumers with fermented products of consistent quality, the use of innovative lactic acid bacteria [LAB] starter cultures for cereal fermentation could be useful for improving the processing of fermented cereal foods. The microbiological characteristics of selected traditional fermented food gruels were identified and proved to be a rich source of beneficial probiotic bacteria strains [92], which can potentially cure children suffering from diarrhea. Capacity building of African food microbiologists and inter collaborative research work between different microbiological laboratories in the different regions will have positive impacts in the short term.

7.4 Linear programming to develop cost-minimized nutritionally adequate health-promoting recipes

Linear programming (L P) tool enables the design of a range of cost-minimized nutritionally adequate health-promoting food recipes that assure the supply of adequate quantities of macro- and micronutrients at the lowest cost is practiced in different settings such as school meals, canteens, prisons, and others [93]. L P is an algorithm for maximizing or minimizing a given (linear) objective function subject to a set of linear constraints [93] on a list of decision variables. The decision variables are whether a food is selected (present or absent) and at what weight. The objective function is to minimize the total cost of the Food recipe (the sum of the cost of each food item in the recipe [93]: 1. Culturally acceptable recipe (CA) follows current eating patterns in the African community; 2. The health-promoting recipe follows the food-based dietary guidelines; 3. Nutritionally adequate recipe

meets all recommended nutrient intake values; 4. Culturally acceptable, nutritionally adequate recipe ; 5. Both health-promoting and nutritionally adequate recipes. In all cases, the goal is to minimize the cost of the recipe. National and international authorities can by using L P methodologies, design dietary guidelines that are more cost-effective in preventing micronutrient deficiencies. The collection of food data includes the prices of each food. Emphasis is given to cheap food commodities with good nutritional qualities such as chicken offal and small cheap fishes. Food composition tables are used for compiling information of the macro and micro composition of each food item. Each food is characterized by its price and its nutrient content. LP tool was used in Ethiopia and Ghana to optimize and identify best ingredients to use based on nutrient needs, cost and local availability of foods and the authors reported that their formula was 60 % cheaper than the traditional RUTF and was well accepted by the children and their mothers[94].

7.5 National authorities and political wills

Political will is needed to undertaking an emerging policy framework to optimize feeding and nutrition practices of the population, with particular emphasis on the young. In the rural areas, the development of policies to promote local agricultural and livestock production of indigenous species at a small-farmer level to increase the availability and access to high yield crops, along with increasing the economic viability of the populations, and preserving the environment through the promotion of biodiversity. Price subsidies and controlled cash transfers, reduced consumption taxes and food-for-work schemes could all be implemented to increase access to better quality animal protein sources. Developing and updating the standards covering quality, as well as physical, chemical and microbiological analyses of food commodities for consumer protection. The access to safe foods through improved marketing and retail activities, transport and storage by mechanical refrigeration. Building institutional capacity to solve the own nutrition problems and adopting the LP methodology for designing cost-minimized nutritionally adequate health-promoting recipes mainly from the local resources, for school meals. Delivery of effective counseling including necessary capacity building and training to evaluate intervention trials.

The African Union is mandated to support and coordinate the utilization and intertrade of livestock and fisheries within the 54 Member States of the African Union as resources for human well-being and economic development the economic viability of the populations, and preserving the environment through the promotion of biodiversity.

Unfortunately, the situation is not so optimistic for some SubSaharan countries according to a report, which stated that by the year 2050 at least 10 countries in the region of sub-Saharan Africa (SSA) would suffer from the greatest food security risk [95]. The assumption of the expert group is based on the current low cereal production and the existence of cereal yield gap. Accordingly, intensification should be successful for self-sufficiency, and not depending on imports of cereals as these countries do today.

Abbreviations

- ASF: Animal sourced Foods
- E: Eastern African region,
- CMAM: community-based management of severe acute malnutrition
- DRC: Democratic Republic of Congo
- ECOWAS: The 15 members of the Economic Community of West African States (ECOWAS) are Benin, Burkina Faso, Cabo Verde, Cote d'Ivoire, The Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, and Togo.
- FBDG: Food-based dietary guidelines
- Glopan: Global Panel on Agriculture and Food Systems for Nutrition
- HLPE: High-Level Panel of Experts on Food Security and Nutrition
- IBFAN: International Baby Food Action Network
- LNS: lipid-based nutrient supplements;
- MAM: moderate acute malnutrition;
- M: Middle or Center African region
- N: Northern African region
- RUSF: ready-to-use supplementary food;
- RUTF: ready-to-use therapeutic foods.
- SAM: Severe acute malnutrition
- S: Southern African region
- S-contg AA: Sulfur- containing amino acid,
- W: Western African region

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